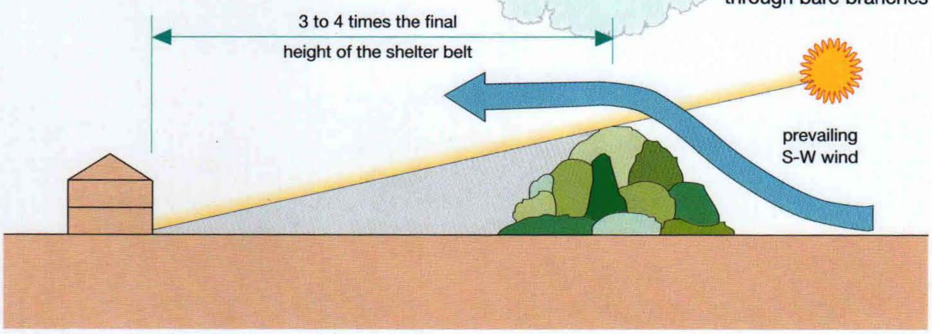
DEPARTMENT OF THE ENVIRONMENT

GENERAL INFORMATION REPORT 27

Passive solar estate layout

- Attractive, sheltered and marketable developments
- Potential energy savings of up to 10% with no extra capital cost
- No conflict with developers' priorities on density, privacy, security and visual appeal



GENERAL INFORMATION REPORT 27

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

INTRODUCTION

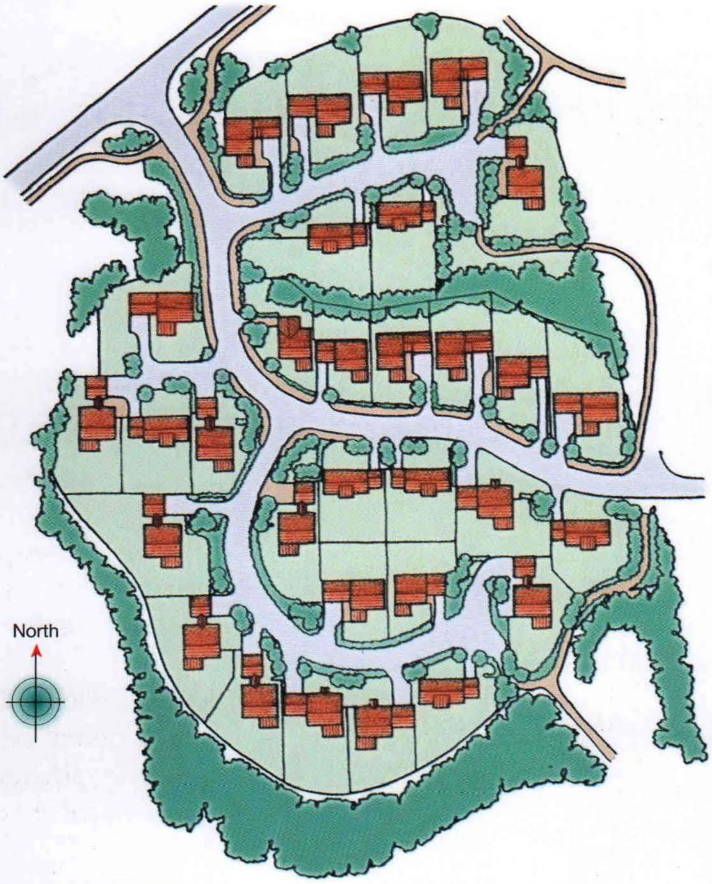


Figure 1 Willow Park, Chorley – an example of a careful but informal layout consisting entirely of passive solar houses having a southerly orientation

Step-by-step changes from 'conventional' to passive solar design	Energy savings (%)
Estate layout	
'Conventionally' planned houses orientated north/south	1 - 3
Estate layout designed to minimise shading from obstructions to solar gain	2 - 4
Typical energy savings from solar estate layout	**3 - 5**
House design	
Glazing biased towards south (for the conventionally planned houses)	3 - 4
Houses replanned internally so that most principal rooms face south	1 - 2
Typical energy savings from passive solar houses on passive solar estates	**8 - 10**

Table 1 Typical energy savings from passive solar design

This Report is intended for designers and developers in both the private and social housing sectors. It discusses site planning and the implications of maximising daylight on landscaping and house design. Illustrations and case study examples show how a few basic design principles can be put into practice.

The Report features houses that are not extreme in any sense. They merely have slightly smaller windows on the north side and collect solar energy through carefully sited windows on the south side. They conform to current insulation standards, and are saleable in current markets.

The aim of passive solar estate design is to plan the layout of roads and individual house plots to take advantage of available sunlight. This is achieved by:

- orientating as many houses as possible so that the elevation with the most glazing faces within 30° of south
- avoiding obstructions in order to maximise solar access to windows.

The greatest energy savings from a passive solar estate layout are achieved by using houses specifically designed for passive solar applications. Up to half the savings come from the estate layout with the remainder coming from designing the house itself to take advantage of solar gains.

Benefits

The reduction in energy consumption achieved by using passive solar designs contributes to a reduction in CO_2 emissions, and hence slows down the increase in global warming. A passive solar estate with all its houses designed for solar gain produces energy savings of up to 10% when compared to a non-solar estate of non-solar houses. Passive solar houses cost no more to build than conventional houses, and the infrastructure of passive solar estates costs no more than for conventional estates.

- Passive solar housing benefits the environment at large by reducing fuel burning, and the individual householder by lowering fuel bills.
- Good estate layout produces warm sunny houses and gardens which are liked by house buyers.

INTRODUCTION

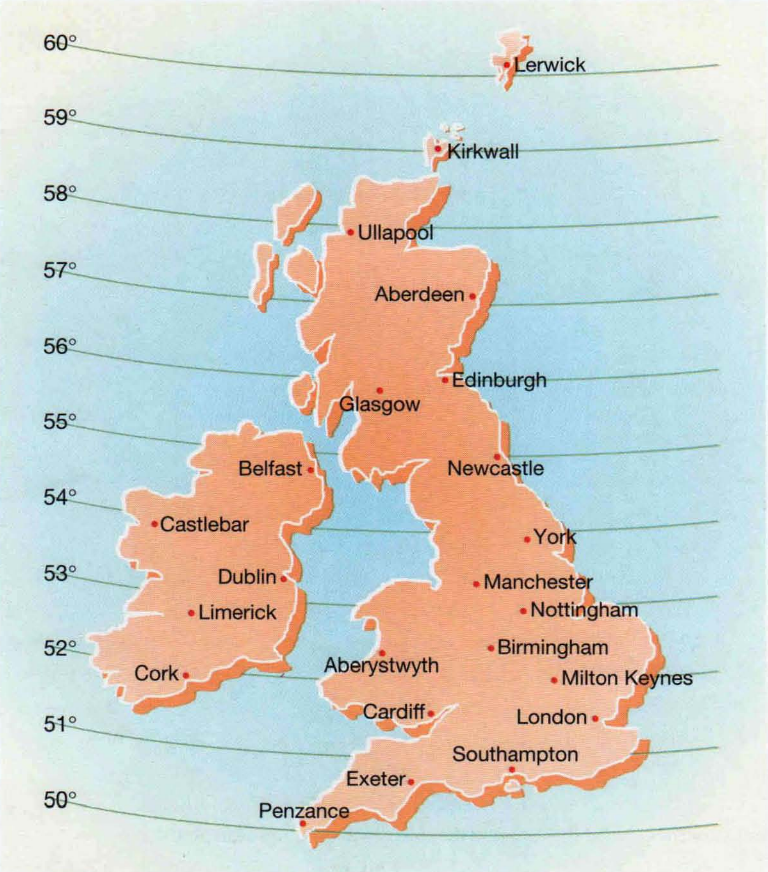


Figure 2 Spacing between houses for good solar access depends on site latitude

		Spacing between houses for minimum of 3 hours solar access per day for the following periods:		
Latitude/typical location		All year	10 months (21 Jan – 21 Nov)	9 months (6 Feb – 6 Nov)
60°N	Lerwick	66 m	40 m	25 m
59°N	Kirkwall	55 m	35 m	23 m
58°N	Ullapool	46 m	31 m	21 m
57°N	Aberdeen	40 m	28 m	19 m
56°N	Edinburgh	32 m	25 m	17 m
55°N	Belfast	31 m	23 m	16 m
54°N	York	28 m	21 m	15 m
53.5°N	Manchester	25 m	20 m	
53°N	Nottingham	25 m	19 m	
52.5°N	Birmingham	24 m	18 m	
52°N	Milton Keynes	23 m	17 m	
51.5°N	London	21 m	17 m	
51°N	Southampton	21 m	16 m	
50°N	Penzance	19 m	15 m	

Table 2 assumes solar access to ground floor windows on a flat site of two-storey houses with 30° pitched roofs

SITE PLANNING – ORIENTATION

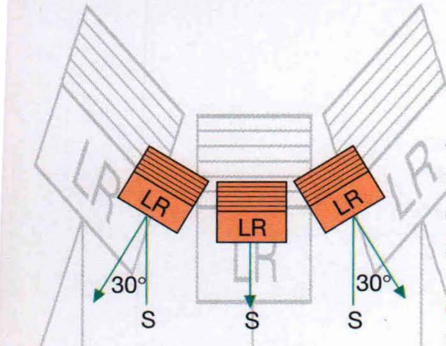


Figure 3 Orientate as many houses as possible within 30° of south. The nearer the orientation is to due south, the greater the solar gains

The two key factors in passive solar estate layout are the orientation of the houses and the degree to which the south-facing glazing is free from overshading.

ORIENTATION OF HOUSES

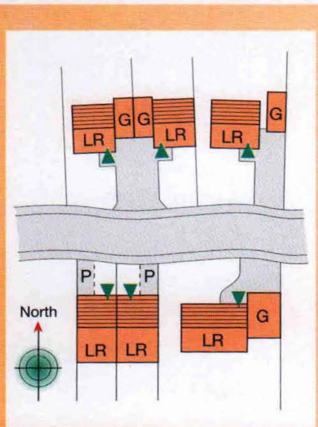
Houses benefit most from solar gains when the principal rooms, such as living-rooms, dining–rooms and main bedrooms have a southerly aspect. It is not necessary to keep rigidly to a due-south orientation, but a good rule-of-thumb is to keep the main glazed elevation within 30° of south.

Houses orientated east of south will benefit more from morning sun, while for those orientated west of south, the afternoon sun can delay the evening heating period.

Houses with a high proportion of south-facing glazing are much more sensitive to orientation than those with more evenly distributed glazing. Studies have shown that changing the orientation from due south to due west increases the heating costs by about:

- 1 to 3% for a conventional house
- 8 to 15% for a passive solar house, because it is designed to have a high proportion of south-facing glazing.

Figure 4 North- and south-entry houses. The importance of orientation to passive solar layouts means that houses naturally fall into two distinct types. Typical developers' plans are illustrated on page 9.



South-entry houses have:

- the entrance on the south, AND
- the living-room on the south.

North-entry houses have:

- the entrance on the north, BUT
- the living-room on the south.

These figures highlight the importance of good orientation when passive solar houses are being used. Where it is not possible to achieve good solar orientation on particular house plots there is little advantage, in energy terms, in using a passive solar house design rather than a conventional design.

ROAD LAYOUT

The road layout is a major factor in determining the orientation of housing within a scheme. For optimum orientation of house plots, roads should preferably be aligned east-west.

East-west roads

Residential roads running east-west produce housing plots with good solar orientation. However, if the houses are to benefit from good orientation, two types are needed:

- *a south entry type* – a house on the north side of the road with its main entrance on the south
- *a north entry type* – a house on the south side of the road with its main entrance on the north.

North-south roads

There are a number of ways in which houses located along roads running north-south can be given southerly orientation. The following most commonly used techniques are illustrated on the opposite page:

- placing larger detached houses one plot deep at intervals along the road
- arranging houses in groups around parking courts or short culs-de-sac off north-south roads.

Diagonal roads

Houses served from roads running northwest-southeast or southwest-northeast also need to be a mixture of north and south entry types. The living-room elevations can be made to face within 30° of south either by skewing the plots in relation to the road or by skewing the houses within the plots.

SITE PLANNING – ORIENTATION

Figure 5 A passive solar layout showing good solar orientation of houses

SITE PLANNING – OVERSHADING

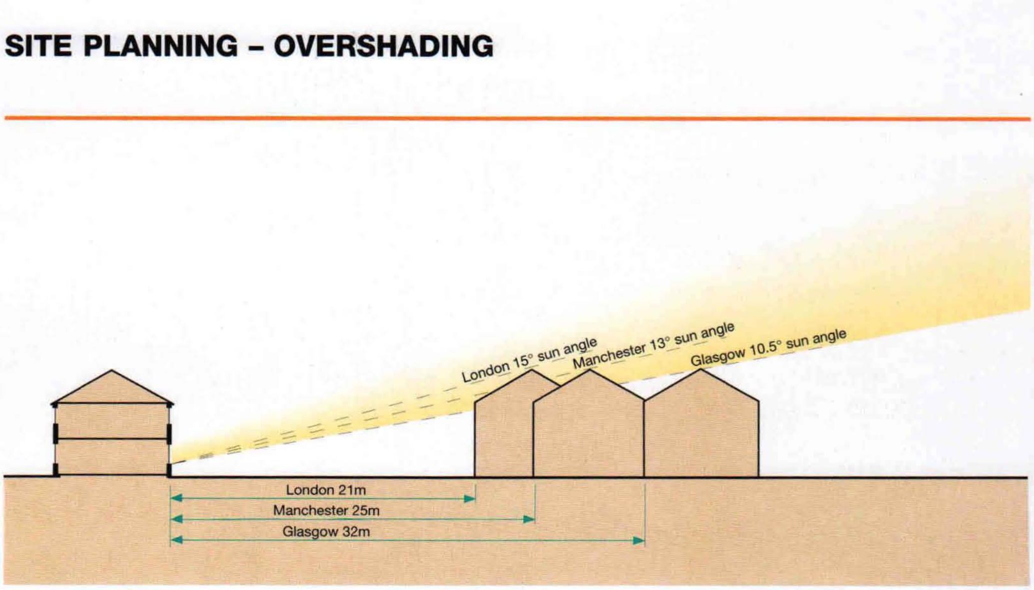


Figure 6 Minimum spacing required for a view of the sun at noon in mid-December at different latitudes, assuming a flat site of two-storey houses with 30° roof pitch

SPACING OF HOUSES

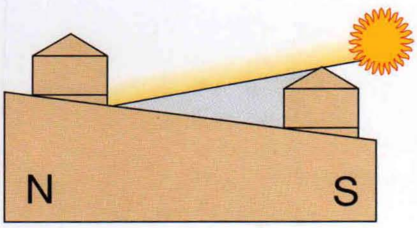
The usual privacy distance adopted between two-storey houses is about 21 m. This spacing produces a density of about 24 dwellings per hectare (dph). For comparison, figure 6 above shows the spacing needed to provide good solar access in mid-winter. It can be seen that in southern Britain, adopting a 21 m privacy distance between houses provides good solar access, but in more northern latitudes, wider spacing is needed if equally good solar access is to be achieved (see table 2 page 3). If these wider spacings cannot be achieved at the more northern latitudes the resulting overshading will lead to higher heating costs. For example, the effect in Glasgow of reducing the distance between houses from 32 m to 21 m would be to increase the heating demand by about 5%.

Overshading

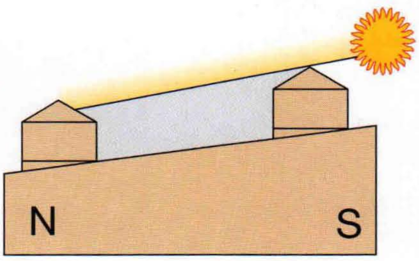
If full advantage is to be taken of a southerly orientation, the site layout should ensure that the south-facing elevations are not obstructed by other buildings or planting. Complete freedom from overshading is rarely possible, but it can be minimised by:

- locating taller buildings to the north of the site or to the south of road intersections or open spaces, such as car parking, which need less or no sun
- locating low-rise buildings, such as bungalows, on the south side of the site
- locating semi-detached and detached housing to the south of the site, to allow some penetration of sunlight between houses
- avoiding obstructions such as projecting garages and porches on the south sides of houses
- locating car parking and garages to the north of housing where possible
- using low-pitched and hipped roofs
- designing planting with height limits in mind.

Figure 7 The slope of the site has a significant effect on overshading



In northern latitudes, south-facing slopes can enable good solar access with reduced spacing



Steep north-facing slopes are unfavourable for passive solar designs

Privacy and security

For south-entry houses which have living-rooms facing the road, the main sunny gardens will be 'front gardens'. These are likely to require privacy screening and planting. This must not be too high if solar access is to be maintained. It may be valuable to site these houses towards the north edge of their plots to maximise the sunny garden space. This increases the distance of the house from the road.

For north-entry houses with living-rooms facing away from the road, the main sunny gardens will be 'back gardens'. Again, it may be beneficial to site these houses towards the north edge of their plots, so that their kitchens are quite close to the road, where they will command a view of the road and contribute unobtrusively to the security of the neighbourhood.

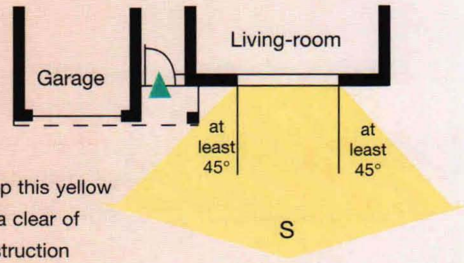
SITE PLANNING – OVERSHADING

Figure 8 Avoiding overshading problems

Projection shading living room window

A. Problem – self shading

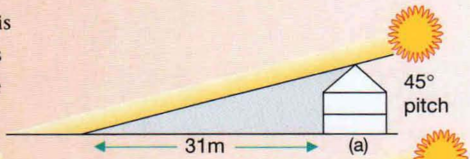
Projections from the south elevation and staggered house plans can shade the living-room window from the sun, and are best avoided

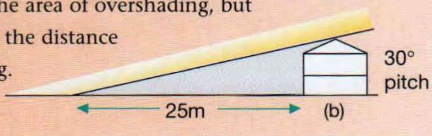


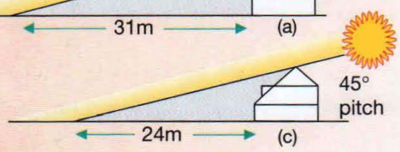
Shaded area to north of high pitched roof

B. Problem – high pitched roofs

Using lower roof pitches (b) reduces overshading. This can also be achieved by constructing the first floor as part of the roof space (c), thus effectively lowering the roof ridge while maintaining the 45° pitch. Hipped roofs reduce the area of overshading, but do not reduce the distance of overshading.



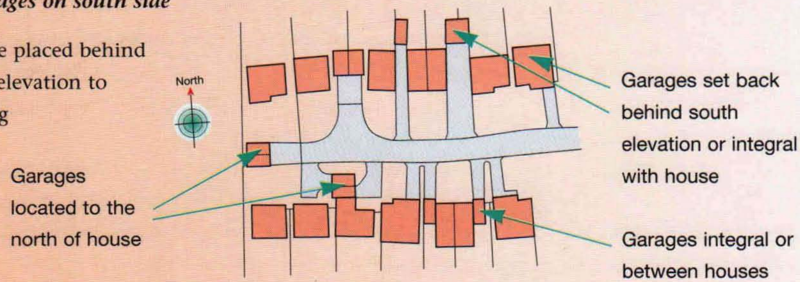




Garage in front of dwelling shading ground floor windows

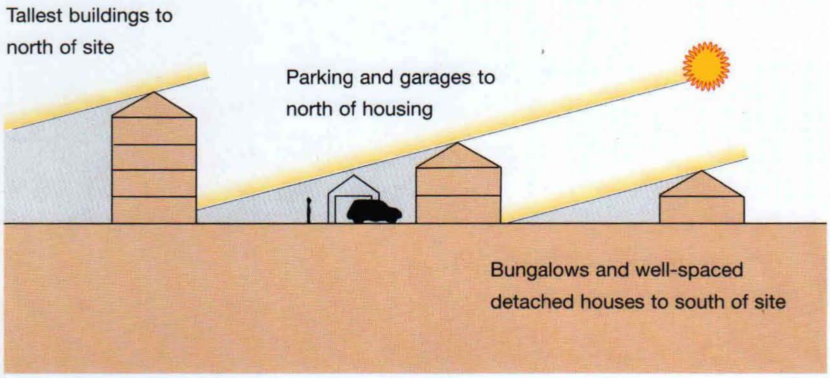
C. Problem – garages on south side

Garages should be placed behind the south-facing elevation to avoid overshading



It is important that an appropriate feeling of privacy for living-rooms is achieved without obscuring the main solar collecting windows. If people feel overlooked they will resort to net curtains and venetian blinds. Their use defeats the object of passive solar design by cutting out about 20% of the solar energy. It is not necessary for passive solar houses to have very large south-facing windows. However, it is important to ensure that glazing area is biased to the south rather than north and that north-facing windows are no bigger than they need to be for adequate daylighting.

Figure 9 Planning to minimise overshading



LANDSCAPE IMPLICATIONS

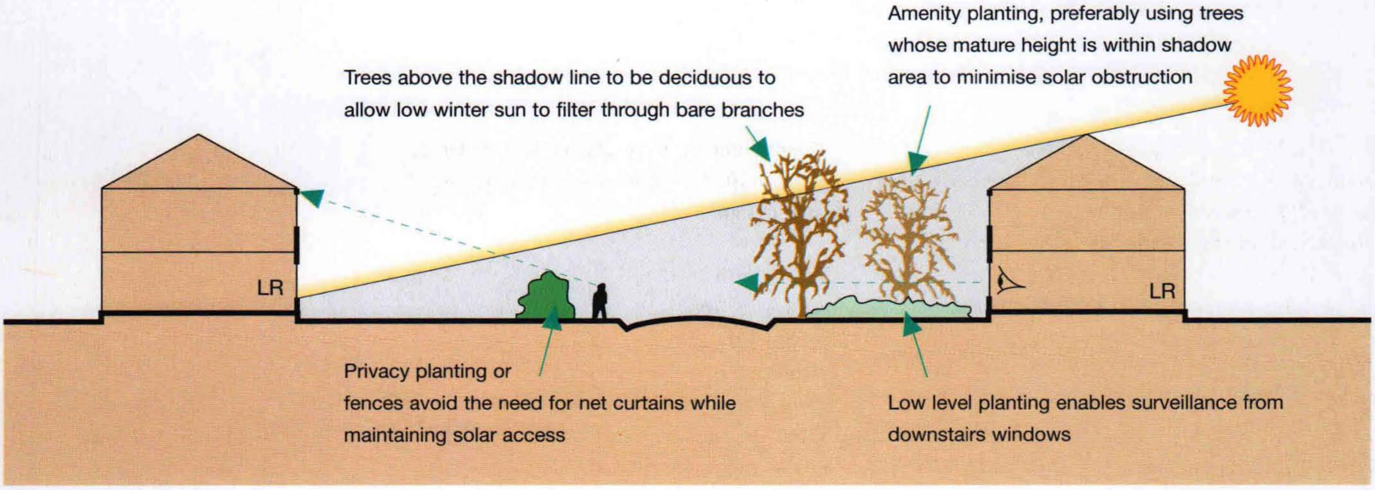


Figure 10 A landscape strategy for passive solar layouts

LANDSCAPING

Planting can improve the amenity of a scheme by providing shelter from cold prevailing winds and creating sun-traps within a scheme. However, if trees and tall evergreen shrubs are positioned so that they overshadow the south-facing elevations of houses, they will negate many of the benefits of a passive solar layout.

The following elements of a landscape strategy complement a passive solar layout:

- ***Shelter belts.*** Trees in shelter belts that protect a scheme from the prevailing south or southwest winds should be spaced at least three or four times their mature height from south-facing elevations to minimise solar obstruction. The tallest trees in the shelter belt should be deciduous, to allow some penetration of low level winter sun. Shelter belts should also be considered to protect the housing from the coldest winter winds, which are normally from the northeast. Evergreen species are better here than deciduous.
- ***Amenity planting.*** Small decorative trees may be planted within public spaces and footpaths, wherever they will not obstruct the solar access of houses. Trees that will eventually grow above the 'shadow line' (see figure 10) such as larger specimen trees, should preferably be deciduous. Deciduous trees can provide shading in summer to limit solar gain and possible overheating, yet allow winter sunshine to filter through the bare branches. Note, however, that it is not good practice to plant trees too close to dwellings – follow advice in the NHBC standards.

Privacy planting should be introduced to the back of footpaths to avoid overlooking south-facing living-room windows. Without this planting, occupants are likely to resort to net curtains and blinds to preserve their privacy, diminishing useful solar gain. Privacy planting can also be provided between back gardens. In both these locations, evergreen shrubs that grow up to about 3m high are suitable.

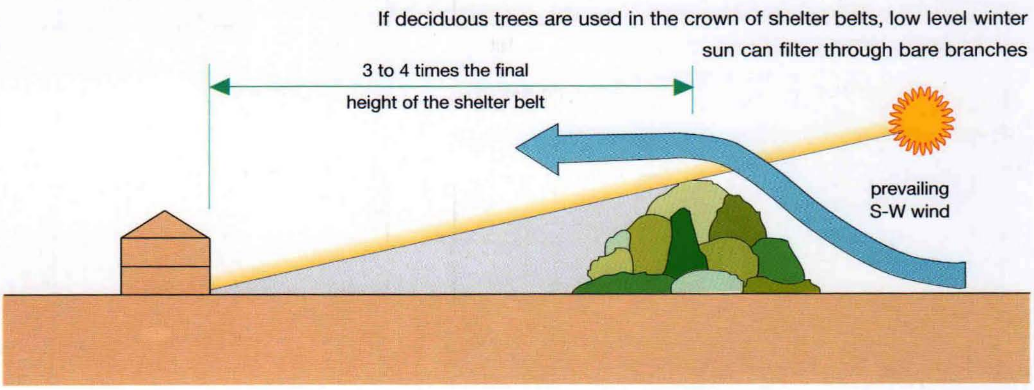


Figure 11 Distance of houses from shelter belts

HOUSE DESIGN IMPLICATIONS

HOUSE DESIGN

A mix of house types, especially both north- and south-entry, is needed in order to make the best use of the different plots within a passive solar scheme. Variety and interest can be added by designing several types of house for each situation. Passive solar houses do not have to be very different from developers' conventional houses (figure 14).

Typical characteristics of passive solar houses

Studies have shown that passive solar houses need not be wide-fronted, but the following features are typical.

- The most heated and frequently used rooms are placed on the south side of the dwelling. The main living-room, being the most useful receiver of solar gain, is always on the south side.
- Rooms that benefit little from sunlight, such as hallways, utility rooms, bathrooms and storage areas, are placed on the north side of the dwelling and have smaller windows.
- South-facing glazing is avoided in the kitchen in order to minimise overheating from a combination of solar gain and internal heat gain.
- Where possible, the dining-room is linked with the living-room in preference to the kitchen, to make best use of solar gain.
- Garages and entrance lobbies act as buffer zones for the heated areas of the house.

Glazing distribution

The orientation of the glazing is a key factor in optimising the energy saving from passive solar design.

To minimise the heating demand, it is beneficial to reduce the area of north, east and west facing glazing - the reduction in heat loss is always greater than the loss of solar gain even where low-emissivity (low-e) glass is used. However, windows should be large enough to provide adequate daylighting, eg they should be at least 15% of a room's floor area.

For sites with good solar access, increasing the area of south-facing double glazed windows is thermally neutral on heating costs for most parts of the country - the extra heat loss through the glazing being balanced by the increased solar gains. However, in colder parts of the country, the heat balance will be slightly negative, while in warmer parts of the country, such as Southwest England, increasing the area of south-facing double glazing will reduce heating costs. Where low-e or other high performance glazing is used, increasing the area of south-facing glazing will generally be beneficial in most parts of the country.

Figure 12 A passive solar house usually has between 60% and 75% of its glazing on the south elevation

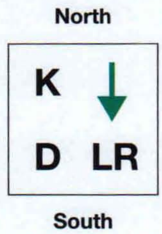


Figure 13 Reduce glazing areas on the north side and keep the main living-rooms on the south side

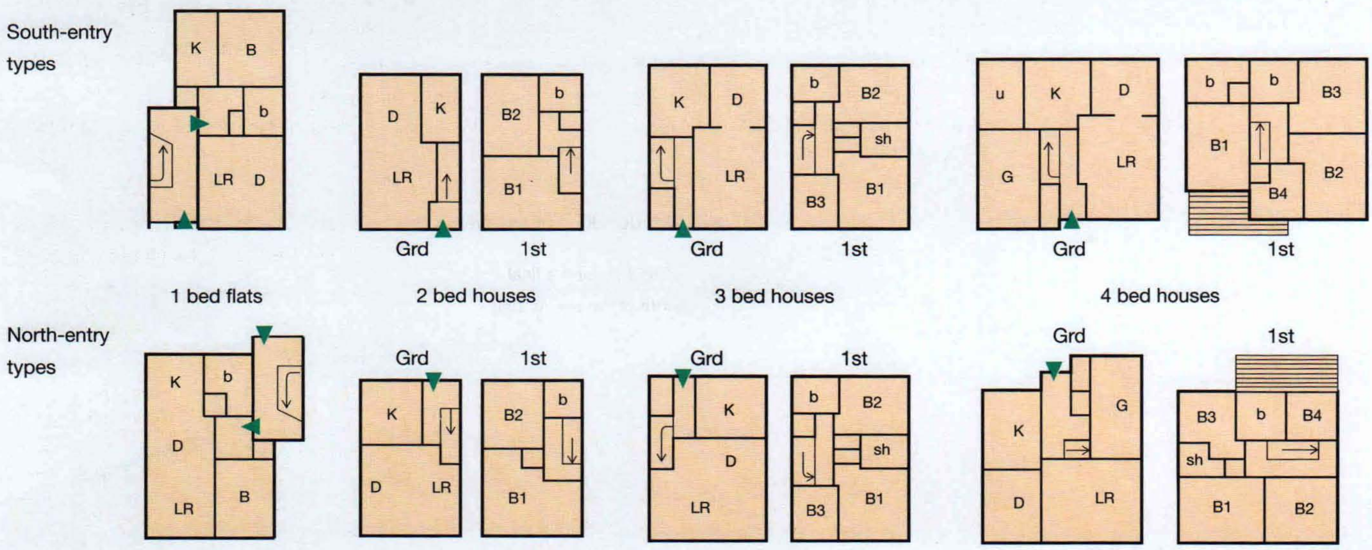


Figure 14 Typical developer plans that are suitable for passive solar layouts

plan of the 'Painswick' (see figure 18)

CASE STUDY 1 – BARRATT HOUSE DESIGNS

Figure 15 Layout 1
Density 21 dph

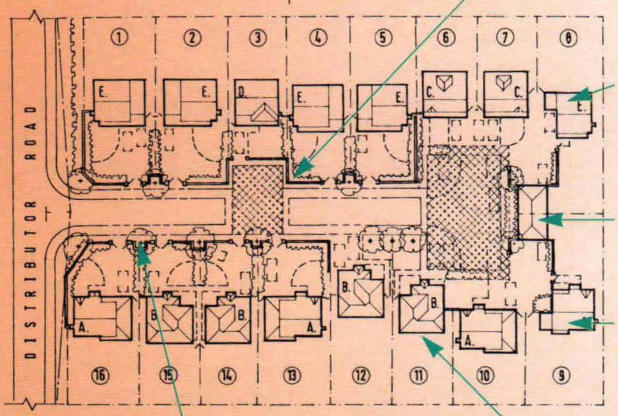
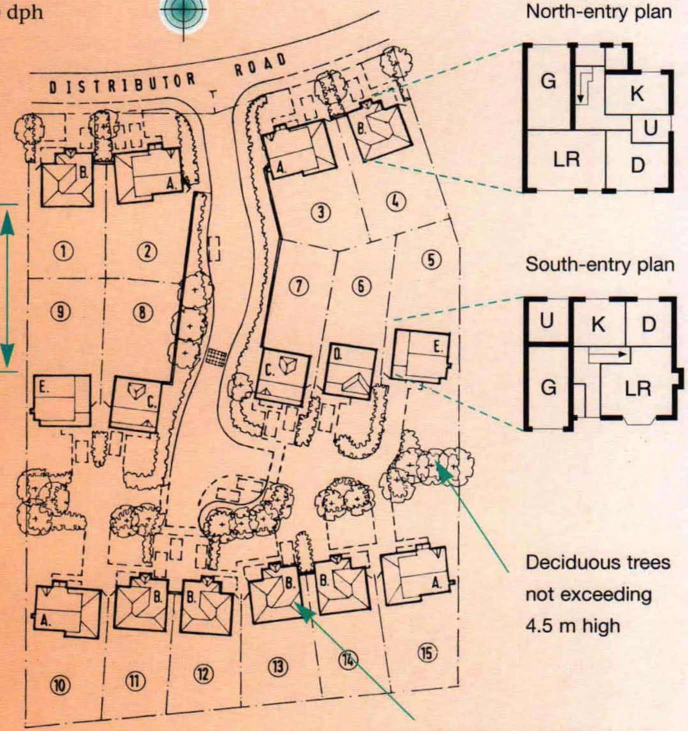


Figure 16 Layout 2
Density 20 dph



This case study shows ways of introducing passive solar design features into two estates for Barratt (Southern Counties). The usual number of houses on the sites was maintained and all the other requirements of the developer were met.

Most of the Barratt house types originally proposed for these sites were south-entry types. To complement these, a new north-entry type was developed. A total of 5 house types were used:

- Type A - an existing north-entry type
- Type B - the new north-entry type
- Types C, D and E - south-entry types.

Layout 1 has a formal east-west road. Variety of form and space is achieved by:

- using five different house types set forward or back on their plots with garages integrated, detached or attached
- handing adjacent similar house types
- using hipped and single-ridged roofs
- introducing variety in hard landscaping.

Layout 2 is less formal and has a marketing and planning requirement for long rear gardens. The layout shows how to provide good solar access for a development with a north-south access road. Varying the houses from due south by up to 20° gives interest and informality. Houses are spaced up to 35 m apart, giving a solar obstruction angle from the ground floor living-room window of only 10°, maximising winter solar gains.

Figure 17 The new north-entry design (figure 16, type B) has 75% of its total glazing on the south side

South elevation

North elevation

CASE STUDY 2 – LOVELL HOMES

This case study of a design by BTP Architects for Lovell Homes shows how a conventional estate layout of detached houses can be replanned using passive solar design principles. In the passive solar layout, the two culs-de-sac are slightly realigned so that the house plots can be reorganised to provide the majority of houses with a southerly aspect. The study clearly demonstrates that a predominantly east-west road layout can give good solar orientation.

In the passive solar layout (figure 19), two–thirds of the houses face within 30° of south and only four houses are orientated east or west. The mix of house types and slight variations in orientation adds variety and informality to the scheme.

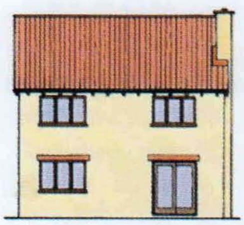
Six basic house types are used. Four are north-entry types and two south-entry. This mix of house types ensures that all houses with a southerly orientation can have their living rooms facing south. The passive solar layout takes advantage of the fact that nearly all the houses are north-entry types by ensuring that their living-rooms look out on to private, sunny, south-facing gardens.

Care will be needed in the selection of tree species if the planting is not to cancel out the gains from the improved solar access.

Figure 20 The 'Painswick' is the most commonly used house type on the Lovell scheme. Although most of the glazing is on the south, the 'front' elevation has good 'kerb appeal' and does not look very different from many developers' 'conventional' houses.

Front (north) elevation windows to:

- kitchen
- entrance hall and WC
- 2 small bedrooms
- bathroom



south elevation windows to:

- living-room
- dining-room
- 2 main bedrooms

Figure 18 Conventional layout

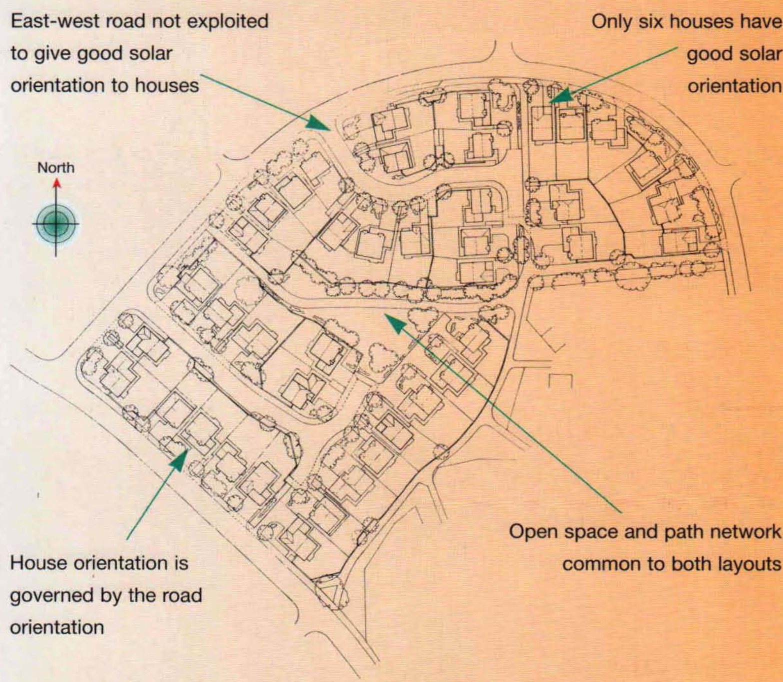
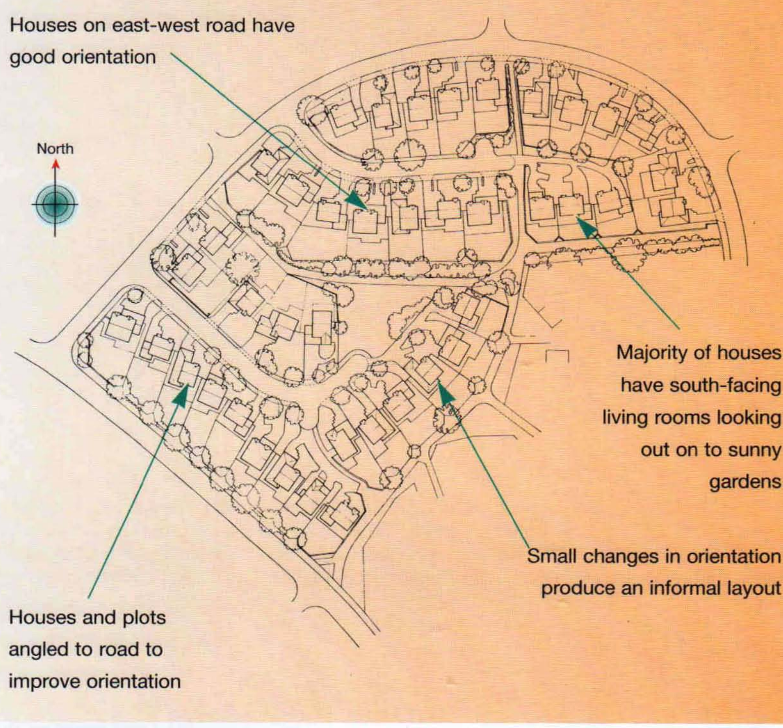


Figure 19 Passive solar layout



FURTHER READING

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Architectural Association. Solar Energy and Housing Design Vols. 1 & 2. Simos Yannas. DTI/Architectural Association, ISBN 1 870890 36 1, 1994 ISBN 1 87090 37X

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DOE ENERGY EFFICIENCY BEST PRACTICE PROGRAMME

The following Best Practice programme publications are available from BRECSU Enquiries Bureau. Contact details are given below.

General Information Leaflets

22 Passive solar house design - Barratt Study

More General Information Leaflets on passive solar house design are planned. Please contact the BRECSU Enquiries Bureau for details.

Good Practice Guide

73 Energy efficient house design – exploiting solar energy

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